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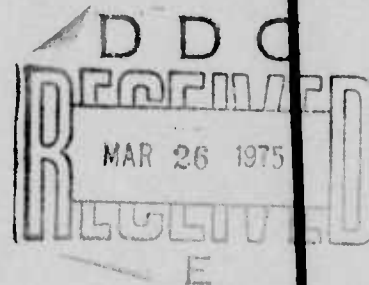


TECHNICAL REPORT AFATL-TR-74-136

**TARGET REFERENCE SYSTEM  
FOR  
RADAR CORRELATION**

**AIR-TO-SURFACE WEAPONS BRANCH  
GUIDED WEAPONS DIVISION**

**AUGUST 1974**



**FINAL REPORT: July 1972 to April 1974**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Radar and radiometric correlators for munition terminal guidance and inflight position fixing require an operationally useful reference map base. A procedure previously developed to convert optical aerial photography into a high resolution radar synthetic map was investigated to determine if it could be extended to synthesis of real-beam radar imagery. Synthetic radar images were generated corresponding to radar scope photographs of Montgomery, Alabama; Richmond, Kentucky; and Laurel, Mississippi. However, based on a visual comparison of the synthetic radar images to the actual radar scope photographs, the results were poor, and it is recommended that the concept not be further pursued.		

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## PREFACE

The activities discussed in this report were conducted by the Applied Math Company of Springfield, Ohio, on Contract FO8635-72-C-0226 with the Air Force Armament Laboratory, Eglin Air Force Base, Florida. The Air Force Program Manager was John P. Richter (AFATL/DLMM).

This technical report has been reviewed and is approved.



JOHN W. JOHNSON  
Deputy Chief, Guided Weapons Division

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## SECTION I

### INTRODUCTION

The usefulness of the concept described in this report was recognized in 1970 during the flight test of ASD Project 4022, Radar Correlation Bombing System (RCBS). In RCBS, the radar bombing crosshairs were automatically positioned by correlating the F-111A radar with a radar reference map of the target area. The reference was prepared from side-looking reconnaissance radar. That source of the reference is undesirable for two reasons: (1) side-looking radar does not produce an image that looks much like that of forward-looking radar and (2) over-flight of hostile territory is required by a manned, vulnerable reconnaissance aircraft before the strike system can operate. The concept demonstrated and reported herein was intended to synthesize an image of a specified radar from maps and optical reconnaissance.

The Applied Math Company, Springfield, Ohio, using their own funds, had previously developed a procedure for transforming an optical aerial image into a synthetic aperture radar image with resolution nearly as good as optical. The results of the procedure were demonstrated by synthesizing a small commercial area.

The objective of the program discussed in this report was to modify the existing process to synthesize a real-beam radar map of a much larger area. If successful, the developed technique could provide a near-term solution to reference preparation requirements for radar map-matching applications.



## SECTION II

### DESCRIPTION OF THE PROBLEM

The Air Force Systems Command is developing radar and radiometric correlators for terminal guidance and for inflight position fixing. One of the most difficult challenges is establishing an operational useful reference map data base for the correlators. The earliest developments, such as MACE, used synthetic radar maps prepared from topographic maps; however, the resultant guidance accuracy was relatively crude by today's requirements. The RCBS used synthetic aperture reconnaissance radar maps, and although the flight test was fairly successful, there are two basic difficulties in using a reconnaissance radar data base:

(a) Correlation accuracy suffers by matching real-beam sensed radar imagery with high resolution stored radar map.

(b) The radar reconnaissance data base is not nearly as complete as an optical data base.

The procedure developed by the Applied Math Company to convert optical aerial photography into a high resolution radar synthetic map was fairly simple and used no specially developed equipment or skills. The process, if it could be extended to synthesis of real-beam radar imagery, would provide a short-term solution to a weapon guidance problem and at a lower cost than other approaches being pursued by the Air Force.



### SECTION III

#### TECHNICAL REQUIREMENTS

The Air Force Project Office had previously obtained radar scope photographs and ground truth of three sample targets at Montgomery, Alabama; Richmond, Kentucky; and Laurel, Mississippi. The contractor was provided certain significant information and was required to generate synthetic radar images corresponding to the existing scope photos. The contractor was provided the Montgomery images for use in calibrating the procedure; however, the Laurel and Richmond images were retained by the Air Force for evaluation of the contractor's product. Both the synthetic images and the scope photos are included in the "Results" section of this report.

The contractor was given the following description of the radar that was used to map the test areas:

- (a) Transmit/Receive Video Frequency: 16 to 16.4 gigahertz (including frequency scan)
- (b) Video Band Width: 5 megahertz
- (c) Pulse Repetition Frequency: 2022 pulses per second
- (d) Pulse Width: 0.4 microsecond
- (e) Antenna Elevation Plane Pattern:  $\csc^2 \theta \cos \theta$  (flattened fan beam - constant gain along the ground)
- (f) Antenna Azimuth Half-Power Beam Width:  $1.6^\circ$

The target area locations and the sensor range, heading, and altitude are as follows:

1. Montgomery, Alabama - This area is centered at latitude  $32^\circ 21' 54''$  N and longitude  $86^\circ 17' 42''$  W. The two sensor locations are:
  - (a) Ground range - 9 N. Mi.; Altitude - 2,000 ft above sea level; Heading -  $260^\circ$  true
  - (b) Ground range - 7 N. Mi.; Altitude - 2,000 ft above sea level; Heading -  $260^\circ$  true
2. Laurel, Mississippi - A 10 mile diameter circle is centered at latitude  $31^\circ 42' 20''$  N and longitude  $89^\circ 08' 4''$  W. The sensor locations are:
  - (a) Ground range - 40,000 ft; Altitude - 3,000 ft above sea level; Heading  $095^\circ$  true
  - (b) Ground range - 63,000 ft; Altitude - 2,750 ft above sea level; Heading -  $243^\circ$  true
3. Richmond, Kentucky - A 10 mile diameter circle is centered at latitude  $37^\circ 35' 42''$  N and longitude  $84^\circ 03' 25''$  W. The sensor locations are:

(a) Ground range - 50,000 ft; Altitude - 2,000 ft above sea level; Heading -  $170^{\circ}$  true

(b) Ground range - 70,000 ft; Altitude - 2,000 ft above sea level; Heading -  $262^{\circ}$  true

The contractor was provided aerial photography and topographic maps of the target areas. The contractor's requirement was to use these photographs and maps to develop the procedure for synthesizing radar maps of the specified area. To demonstrate the ability to accommodate terrain effects, two separate headings on each target area were synthesized. In all cases, the radar beam grazing area was less than  $5^{\circ}$  below horizontal.

## SECTION IV

### RESULTS

Figures 1 through 6 show the radar synthetic maps prepared by the contractor (top views) and the actual scope photographs (bottom views) from the same location in space. Flight direction of each is from the bottom of the page to the top. The single fiducial marks on the synthetic images are the cardinal directions. The double fiducial mark is the specified heading corresponding to the azimuth cursor on the actual radar image. The target point whose coordinates are specified in Section III is at the intersection of the cardinal fiducials on the synthetic images, and at the intersection of the range and azimuth cross hairs on the actual radar images.

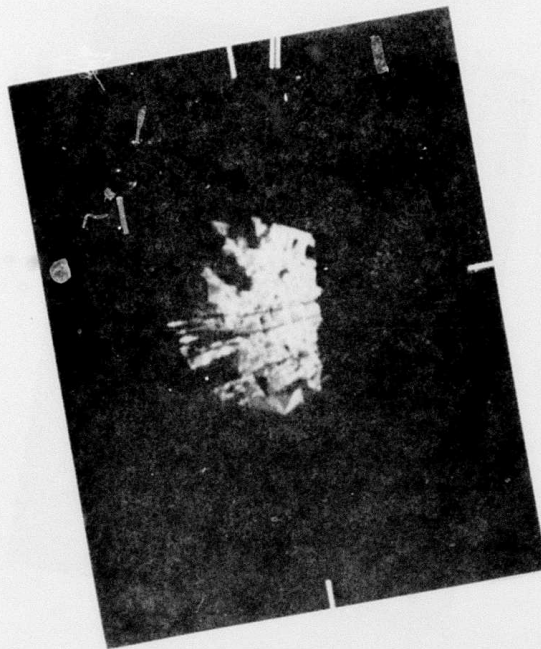
The synthetic images each cover a 10 nautical mile area centered on the target. The scale on the Montgomery and Laurel scope photographs is 15 nautical miles from the nadir to the top of the display. The Laurel scope photographs cover an area 10 nautical miles in diameter, centered on the target.

The contractor has been provided the actual radar images of the Montgomery area to calibrate his procedure but had not had access to the Laurel or Richmond images at the time the synthetic radar map was delivered.

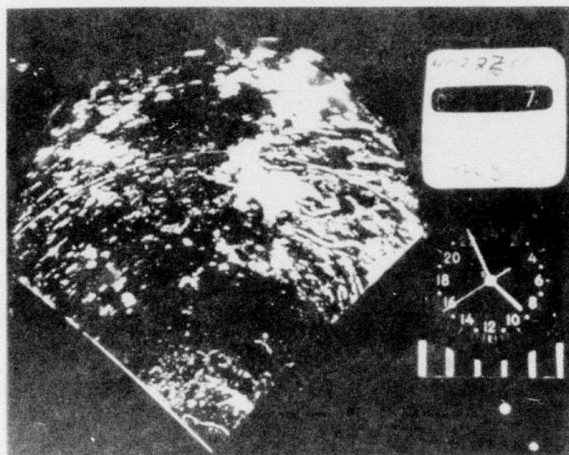
## SECTION V

### CONCLUSIONS

Visual comparison of the synthetic radar image to the actual radar scope photograph is considered poor; although this concept has previously been demonstrated for syntheses of high resolution radar maps. The concept of adapting this procedure for syntheses of real beam radar maps is not feasible and should not be further pursued.



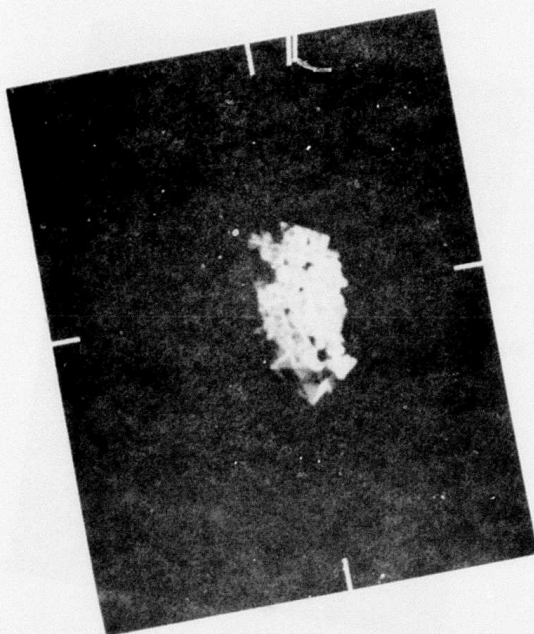
(a) Synthetic



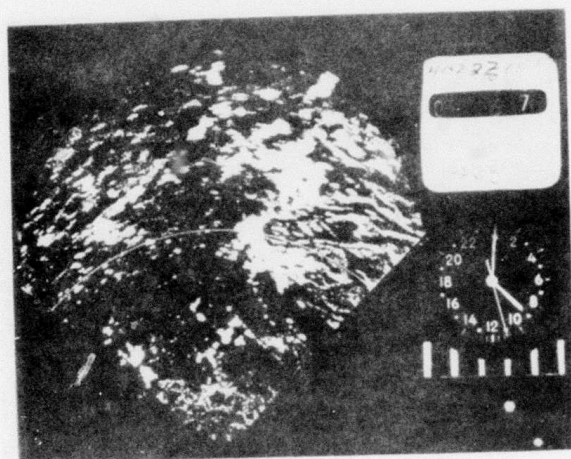
(b) Actual

Figure 1. Montgomery, Alabama, Heading:  $260^{\circ}$ , Range: 9 Miles, Altitude: 2,000 Feet



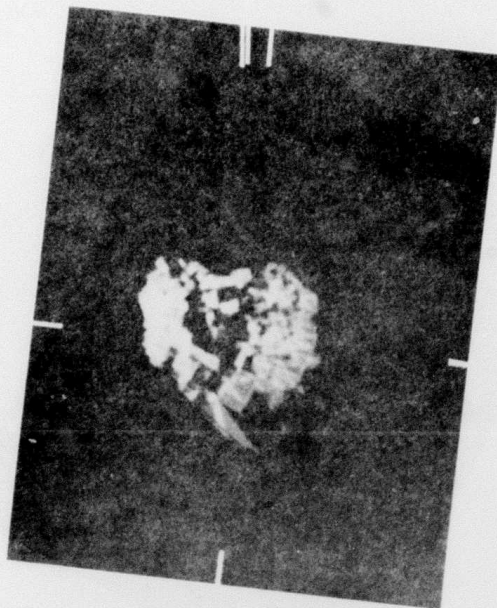


(a) Synthetic

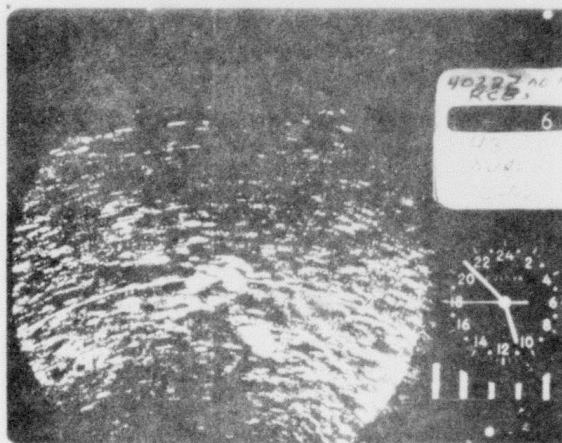


(b) Actual

Figure 2. Montgomery, Alabama, Heading:  $260^{\circ}$ , Range: 7 Miles, Altitude: 2,000 Feet



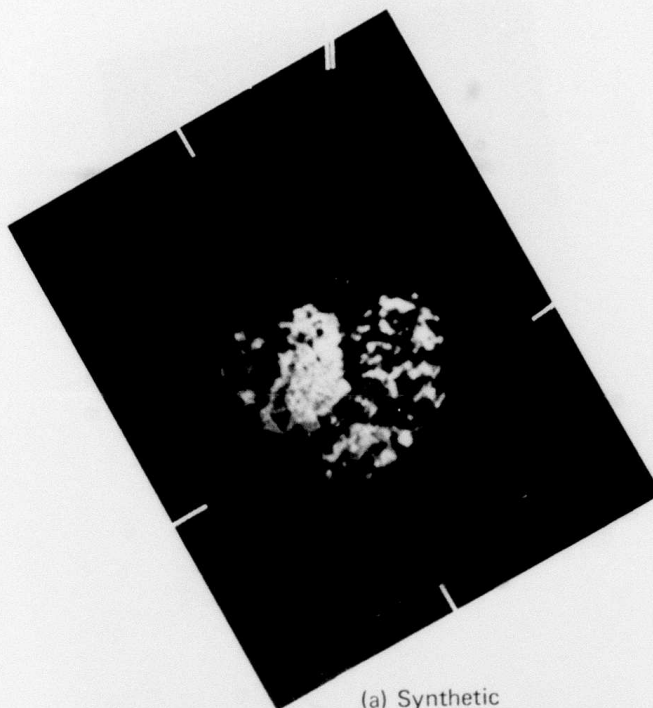
(a) Synthetic



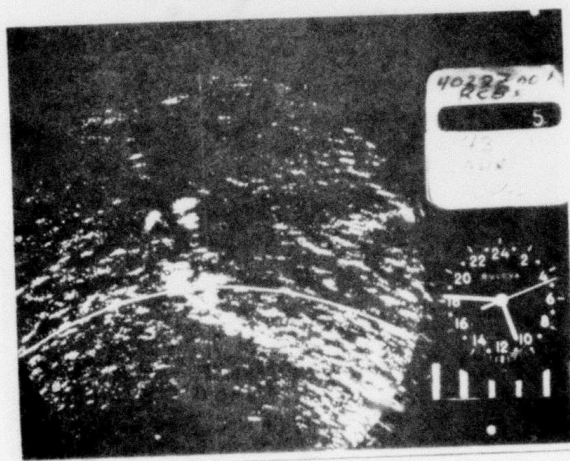
(b) Actual

Figure 3. Laurel, Mississippi, Heading:  $095^{\circ}$ , Range: 7 Miles,  
Altitude: 3,000 Feet



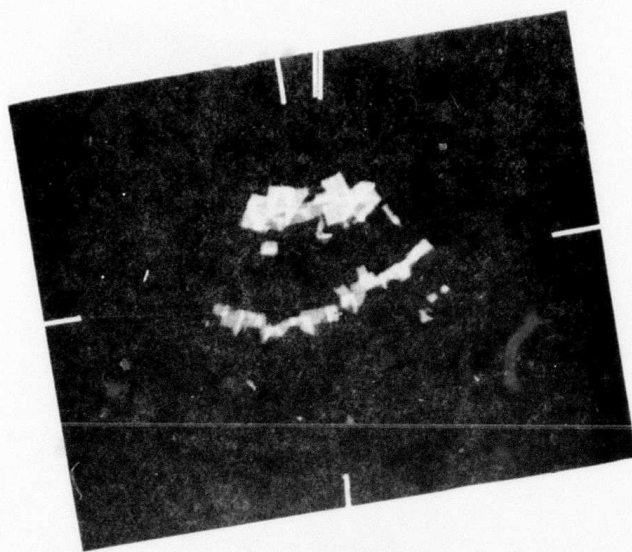


(a) Synthetic

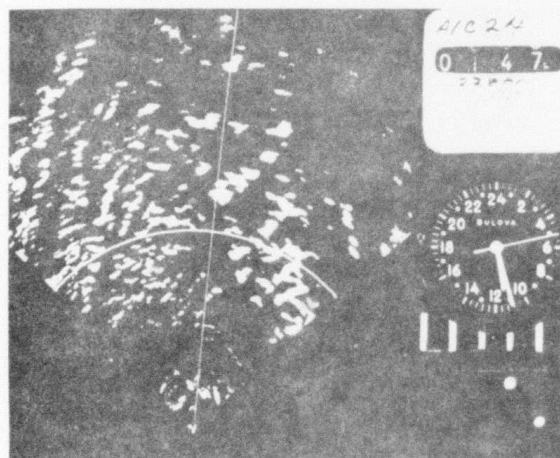


(b) Actual

Figure 4. Laurel, Mississippi, Heading:  $243^{\circ}$ , Range: 10 Miles, Altitude: 2,750 Feet



(a) Synthetic

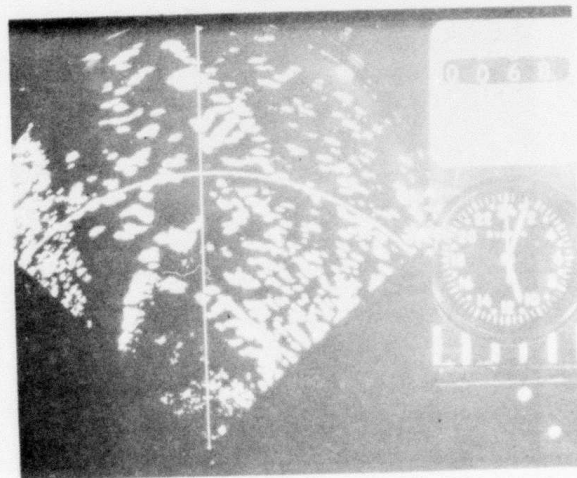


(b) Actual

Figure 5. Richmond, Kentucky, Heading:  $170^{\circ}$ , Range: 9 Miles, Altitude: 2,000 Feet



(a) Synthetic



(b) Actual

Figure 6. Richmond, Kentucky, Heading:  $262^{\circ}$ , Range: 12 Miles, Altitude: 2,000 Feet

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